# Brake wear particles: effects of braking intensity, frequency and temperature

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## MOTIVATION

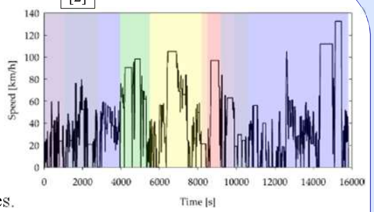
- Traffic-derived emissions is the main source of particulate matter in the urban area.
- On road particle emissions can be classified in exhaust particles (EP), due to fuel combustion and lubricant volatilization during the combustion process, and non-exhaust particles (NEP), related to the mechanical abrasion of brakes and tires.
- The proportion of NEP has increased with respect to the EP due to the improvement of the exhaust emission after-treatment systems and the use of more environmentally friendly fuels.
- In view of the intensification of the electrification in the road transport a further growth on the non-exhaust contribution is forecast because of the extra weight of the batteries.

[1]


## BACKGROUND

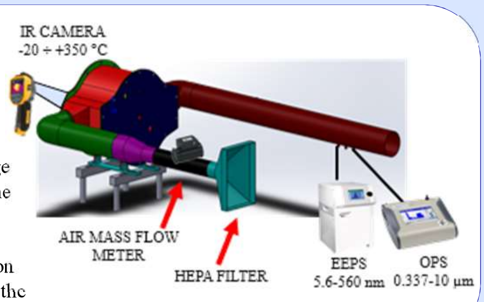
- The Informal Working Group on Particulate Measurement Programme (PMP-IWG), has developed a method for sampling and measuring brake particulate matter and particle number emissions from light-duty vehicles.
- An initial regulation may be incorporated into the new Euro 7 standard.
- A PM10 limit of 7 mg/km has been set. PN emission limits will be introduced later.

[2]

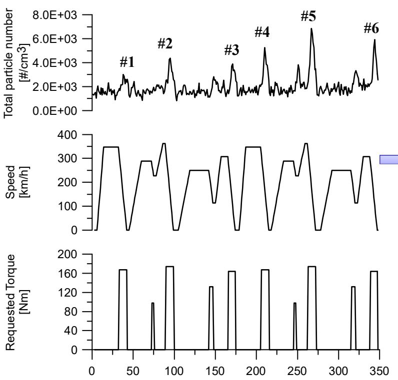


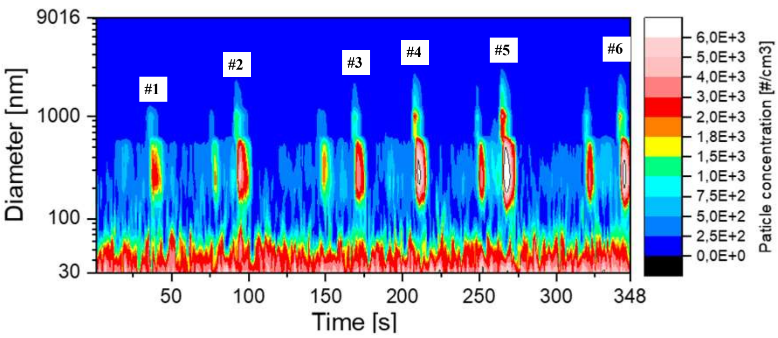

## METHODOLOGY

- Box design for particles measurement under controlled temperature and humidity conditions.
- Partilce measurement in the range from 5.6 nm to 10 μm through the simultaneous use of EEPS and OPS.
- Infrared camera for the correlation of particle number and size with the disk temperature.



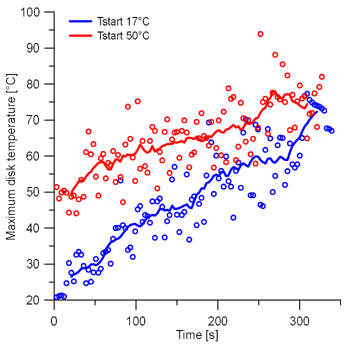

## EXPERIMENTA RESULTS



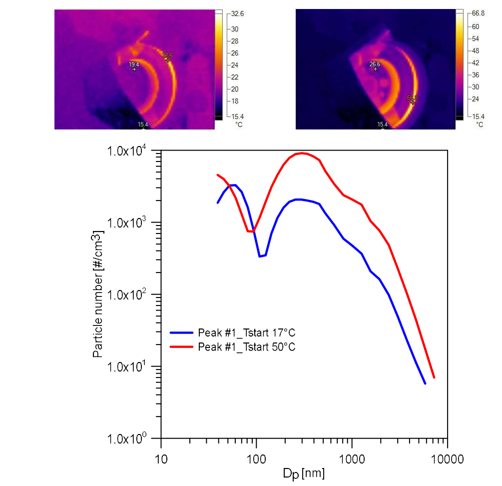

- High particle concentration measured in correspondence with the braking event for a typical urban braking cycle.
- Particles have diameters in the size range 30 nm – 11 μm.
- Particles show a well-defined bimodal size distribution. The first peak is centered around 40 nm and the second and higher peak around 300 nm.

- Maximum temperature profile of the disk along a typical urban braking cycle.
- Comparison of the temperature profiles at two different starting temperature of the disk, 17 and 50 °C.

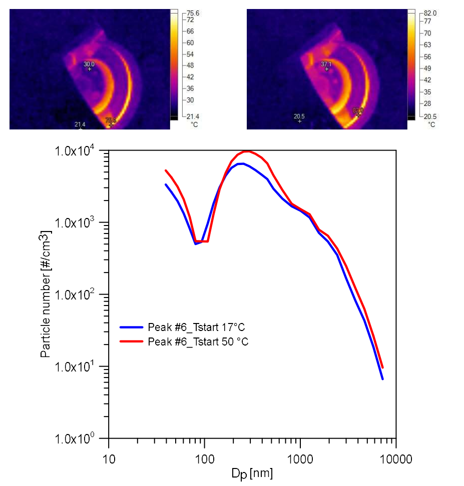



- Particle size distribution at two different disk temperature: higher is the brake temperature, higher is the particle emission.

$T_{max}$ peak#1 @ Tstart 17 °C: 32 °C  $T_{max}$ peak#1 @ Tstart 50 °C: 66 °C




$T_{max}$ peak#6 @ Tstart 17 °C: 77 °C  $T_{max}$ peak#6 @ Tstart 50 °C: 82 °C




## FUTURE PERSPECTIVES

- Disk and pad material formulation to restrain the mechanisms of particle formation.
- Optimization of the brake profiles through proper control systems to reduce the particle emissions.

## REFERENCES

[1] Piscitello A, Bianco C, Casasso A, Sethi R. Non-exhaust traffic emissions: Sources, characterization, and mitigation measures. Sci Total Environ 2021;766:144440. https://doi.org/10.1016/j.scitotenv.2020.144440

[2] Mathissen M, Grochowicz J, Schmidt C, Vogt R, Farwick zum Hagen FH, Grabiec T, et al. A novel real-world braking cycle for studying brake wear particle emissions. Wear 2018;414–415:219–26. https://doi.org/10.1016/j.wear.2018.07.020.